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(56) Documents Cited
EP 0653219 A1
US 5566669 A
US 4353366 A
US 4108172 A
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(58) Field of Search
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(54) Abstract Title
Apparatus for administering oxygen to a subject

(57) Apparatus for administering oxygen or air to a subject 43 in the form of a mask, a helmet, a connector, a mouthpiece or an airway 42 including a filter 9, 48, 49, 52 for the removal of carbon dioxide from exhaled oxygen or air.

The filter may be a chemical filter containing lithium hydroxide, potassium hydroxide, sodium hydroxide or soda lime. Alternatively, the filter comprises a molecular sieve.

The apparatus may further comprise adjuster means such as a rack and pinion arrangement to assist or hinder inhalation and/or exhalation of the subject in use the apparatus.

Hydrogen peroxide or compressed oxygen may be used as a source of oxygen.

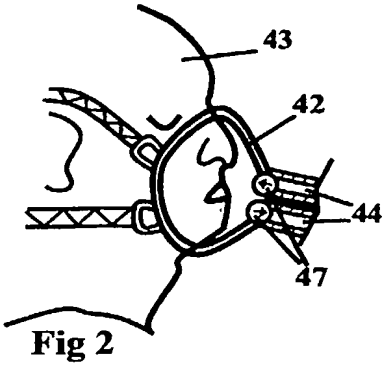

Fig 2

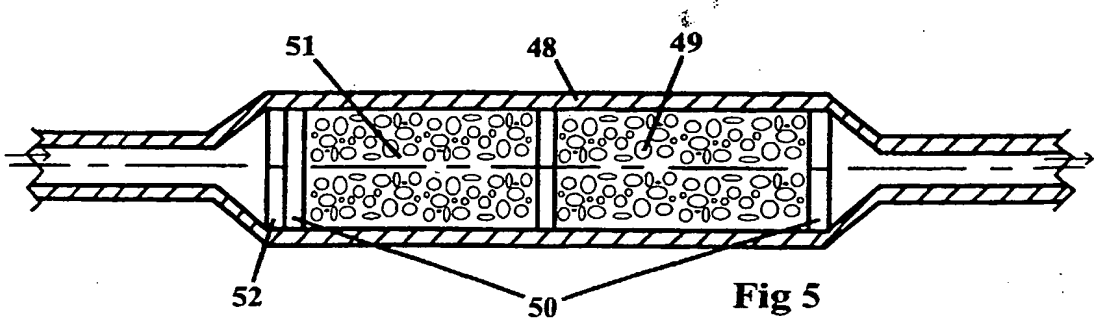

Fig 5

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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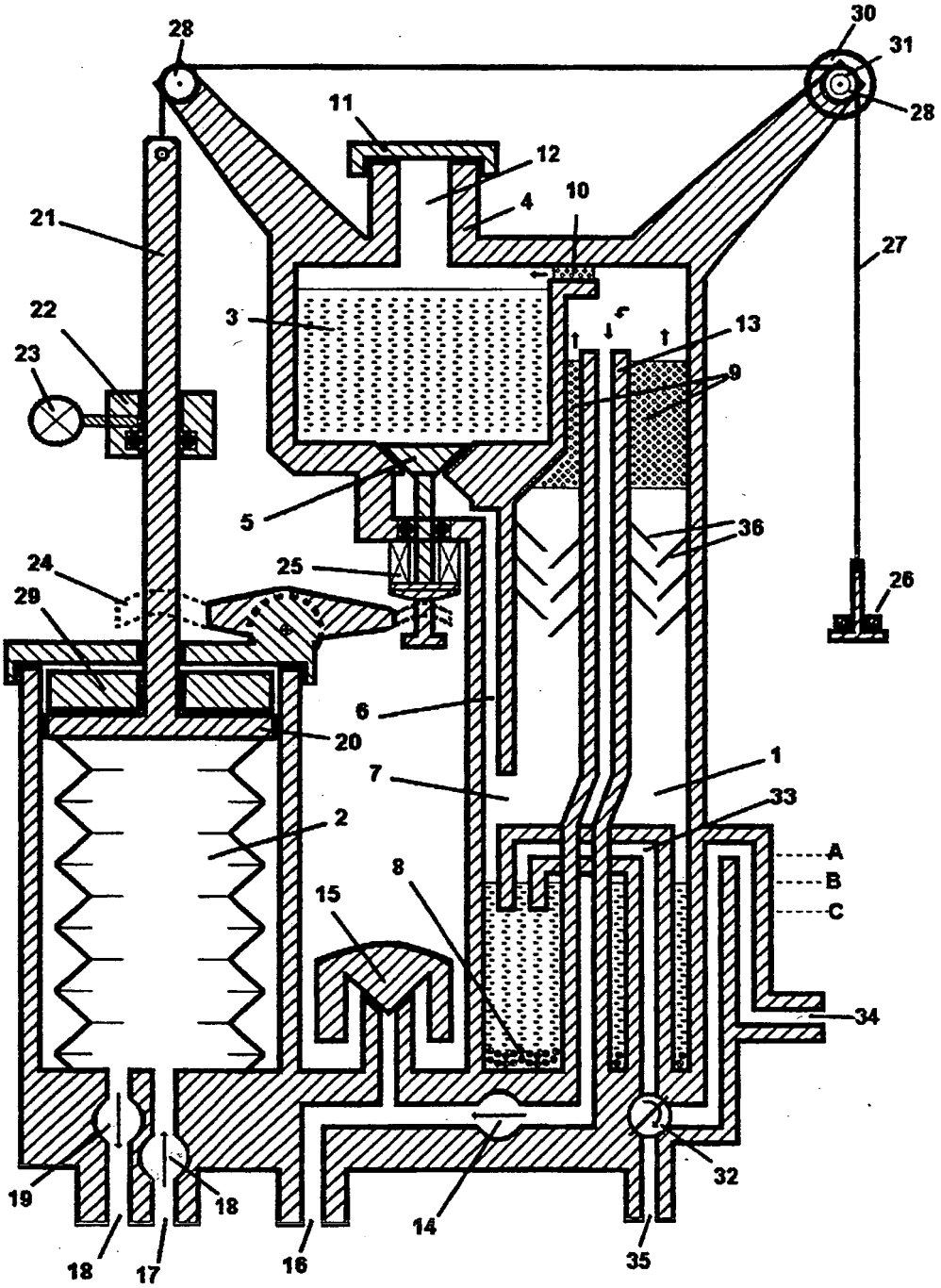

Fig 1

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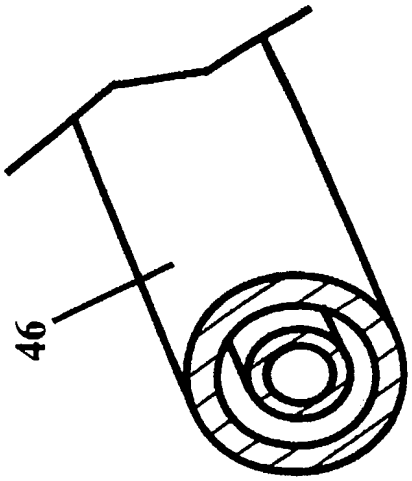

Fig 4

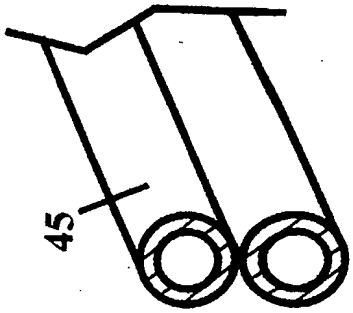

Fig 3

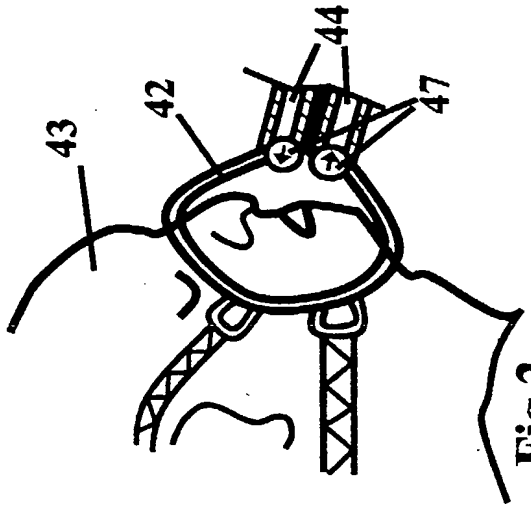

Fig 2

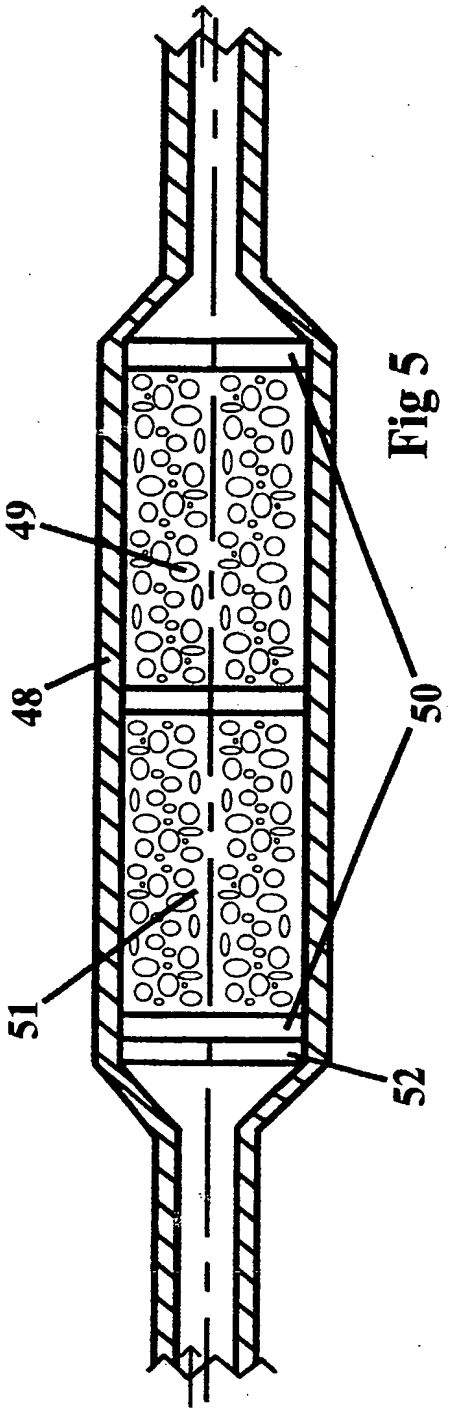

Fig 5

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APPARATUS FOR ADMINISTERING OXYGEN TO A SUBJECT

This invention relates to apparatus for administering oxygen to a subject. More specifically, the apparatus may be used for administering the oxygen for respiratory or ventilation purposes.

It is well known that clean fresh air is composed by a volume of 80% nitrogen, 20% oxygen, 0.04% carbon dioxide, and very small traces of rare gases. Fresh air usually contains some water in the form of water vapour.

In normal unforced respiration, a healthy human adult is able to inhale and exhale a volume of approximately 0.5 litres, 14-18 times per minute. The exhaled air contains approximately 4.0% of carbon dioxide. The exhaled air will have been warmed to 37°C, and it will be saturated with water vapour. If a relatively small volume of air were repeatedly to be breathed in and out from a collapsible air reservoir such for example as a bag, then the concentration of oxygen in the air would rapidly fall to dangerously low levels, and the concentration of carbon dioxide would rapidly rise to dangerously high levels. Condensation would form on the inside of the reservoir. There would be no net change in the volume of air contained within the reservoir (provided the air in the reservoir was

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initially at body temperature) since the volume of oxygen absorbed would be identical to the volume of carbon dioxide exhaled.

Different types of oxygen administration apparatus are known. The most usual type of administration currently employed involves supplying a person with either pure oxygen, oxygen enriched air, or nitrogen mixture supplied via pressure and flow regulating apparatus from one or more high pressure cylinders to a mask, a mouthpiece, an airway, a helmet or a chamber. The most efficient type of known oxygen administration apparatus, in terms of efficiently getting oxygen into the subject, incorporates a demand type valve, which avoids gas being wasted when the person is not inhaling. With most known oxygen administration apparatus, the exhaled air (which includes oxygen) is exhausted to the atmosphere. Even a healthy person breathing pure oxygen, only adsorbs 4.0% of the volume inhaled. It can therefore be seen that even the best known type of oxygen administration apparatus fails to utilize 96% of the oxygen that is being consumed.

It is an aim of the present invention to reduce the above mentioned problem.

Accordingly, in one non-limiting embodiment of the present invention there is provided apparatus for administering oxygen to a subject, which apparatus comprises connector means for connecting the apparatus to the subject such that the subject can inhale the oxygen,

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and filter means for filtering out carbon dioxide exhaled by the subject, the apparatus being such that the carbon dioxide is exhaled into the apparatus and mixes with the oxygen, the apparatus being such that the carbon dioxide is filtered by the filter means so that the oxygen remains substantially uncontaminated by the carbon dioxide and thereby remains suitable for inhalation.

The apparatus of the present invention is thus highly efficient because substantially all of the oxygen is available substantially all of the time for use. The prior art problems of the concentration of oxygen in the air falling to dangerously low levels and the concentration of carbon dioxide rising to dangerously high levels are able to be avoided. The subject may be a person or an animal.

Preferably, the connector means is a mask, a mouthpiece an airway, a helmet, or a chamber which either fully or partially encloses the subject. This chamber may be an infant incubator chamber.

The filter means may be a chemical filter means. A presently preferred chemical filter means is lithium hydroxide, potassium hydroxide, sodium hydroxide or soda-lime. The soda-lime is a mixture of calcium oxide with 5-20% sodium hydroxide and 6-18% water by weight. As an alternative to the chemical filter means, the filter means may be a molecular sieve filter means.

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The apparatus may include passage means extending between the connector means and the filter means. Preferably, the passage means is a flexible tube.

The apparatus of the present invention may include adjuster means which is such that it can be adjusted for assisting or hindering inhalation and/or exhalation as may be desired.

The adjuster means may be a counter balance device which is such that at balance it neither assists nor hinders the inhalation and/or the exhalation, and which is also such that it can be adjusted for assisting or hindering inhalation and/or exhalation as may be desired. Alternatively, the adjuster means may comprise a motor driving a rack and pinion arrangement. Other types of adjuster means may be employed.

The apparatus of the present invention may include a source of oxygen. The source of oxygen may be hydrogen peroxide or compressed oxygen. Other sources of oxygen may be employed if desired.

Preferably, the apparatus is portable apparatus but it may be static apparatus if desired.

Embodiments of the invention will now be described solely by way of example and with reference to the accompanying drawings in which:

Figure 1 is a section through part of first apparatus for administering oxygen to a subject:

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Figure 2 shows another part of the apparatus for administering oxygen to a subject;

Figures 3 and 4 show two different types of passageway means; and

Figure 5 is a section through an alternative type of filter means that may be employed in the apparatus of the invention.

Referring to Figures 1 and 2, there is shown apparatus for administering oxygen to a subject in the form of a person 43. The apparatus is designed to provide a wide range of adjustable respiratory perameters. The apparatus may operate as a respirator or as a ventilator.

As shown in Figure 1, the apparatus comprises a source of oxygen in the form of oxygen generating apparatus 1. The oxygen generating apparatus 1 is capable of supplying oxygen on demand, via various passages, valves and filters, to a bellows reservoir device 2. The bellows reservoir device 2 in turn supplies a person as shown in Figure 2 with either pure oxygen, or an oxygen enriched mixture of gases such for example as air and oxygen or nitrogen, or helium and oxygen.

The apparatus shown in Figure 1 is such that the oxygen concentration is maintained within set limits, and the carbon dioxide exhaled is substantially eliminated. For efficient function, the respiratory tract must be hermetically sealed to the apparatus. This is achieved by

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using a hermetically sealing mask 42 as shown in Figure 2. As an alternative to the hermetically sealing mask 42, a hermetically sealing helmet, airway or mouthpiece (requiring the use of nasal bungs or clips) may be employed. As a further alternative, the apparatus shown in Figure 1 may communicate with a chamber totally enclosing the apparatus and all of the relevant part of the person 43.

The apparatus shown in Figures 1 and 2 operates as follows. Hydrogen peroxide in aqueous solution 3 is contained in a reservoir 4. The concentration of the solution may be up to 100% weight/volume. A presently preferred concentration is 9% weight/volume. This concentration produces a volume of oxygen equal to 30 times its own volume upon decomposition. A 30% weight/volume solution produces 100 times its own volume of oxygen upon decomposition.

The hydrogen peroxide solution 3 is metered upon demand via a valve member 5 and a transfer passage 6 to a reaction chamber 7. In the reaction chamber 7, the hydrogen peroxide solution 3 is catalytically decomposed by one of a number of suitable catalysts 8. Examples of such catalysts include manganese dioxide, lead, and organic enzymes of the peroxidase class, as contained in animal sources such as liver and vegetable sources such as horseradish root.

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Steps may be taken to avoid catalyst loss when the reaction chamber 7 is drained. These steps may include pelletisation or surface adsorption of the catalyst so that the catalyst is retained in the reaction chamber 7. The drainage system may employ a siphonic system as shown such that the reaction chamber 7 is not fully drained, thereby to enable the catalyst to be retained.

In the reaction chamber 7, a vigorous reaction occurs according to the equation:

$2H_2O_2$ + catalyst = $2H_2O$ + O_2(gas).

The reaction causes the reactants to effervesce. The oxygen gas liberated is saturated with water and is in the form of an aerosol. The oxygen and the droplets of water ascend the reaction chamber 7 and pass around spray deflecting, aerosol-precipitating vanes 36. These vanes 36 remove most of the water droplets from the oxygen.

The oxygen then passes through a porous plug 9 which precipitates any residual water droplets. The porous plug 9 may be in the form of fine metal or glass, mesh, wool, porous ceramic material, glass or plastics fritt, or sintered metal.

A communication between the hydrogen peroxide reservoir 4 and the reaction chamber 7 includes a porous plug 10. The reservoir 4 is fitted with a hermetically sealing closure 11. The communication serves to equalize the pressure in a headspace 12 of the reservoir 4 with the pressure prevailing within the reaction chamber 7. This is

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so that the hydrogen peroxide is able to feed into the chamber 7 under gravity, even when the pressure in the chamber 1 is above atmospheric pressure. An oxygen generator of this type is capable of delivering oxygen at any pressure, to hundreds of atmospheres if suitably constructed.

The oxygen then flows into and down a collector tube 13 and, via an optional non-return valve 14, to an optional pressure release valve 15. The oxygen, still saturated with water vapour, then exits the apparatus at port 16. The oxygen from port 16 passes via a tube or passage (not shown) to an optional cold trap and/or Drechsel bottle assembly (not shown) and an optional water adsorption filter (not shown) to a tube or passage (not shown) and then to the bellows reservoir device 2 via an entry port 17 and an optional non-return valve 18.

During operation of the apparatus as shown in Figures 1 and 2, the person 43 is fitted with the illustrated hermetically sealing mask 42. This mask may alternatively be a mouthpiece, an airway, a helmet or a chamber. The mask is fitted with two tubes 44 as shown in Figure 2. The mask 42 may alternatively be fitted with a bi-axial tube 45 as shown in Figure 3, or a co-axial arrangement of tubes 46 as shown in Figure 4. In the case of the tubes 44, they may be fitted with non-return valves 47 as shown. Alternatively, the non-return valves 47 may be integral with the mask 42. If the tubes 45 or 46 are employed,

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then the mask, the tubes or appropriate connecting unions must be fitted with non-return valves, such that one tube functions as an inlet and the other tube functions as an outlet.

The distal end of the tubes 44, 45 or 46 is such that the tube carrying air or gas from the person 43 has an entry end of an optional drechsel bottle and/or cold trap (not shown). The drechsel bottle and/or the cold trap communicate with the entry end of a filter 48 as shown in Figure 5, or a series of filters (not shown). The minimum requirement of the filter 48 or the series of filters is substantially to remove the carbon dioxide from the expired air, gas or gases. This is achieved by allowing the air from the gas or gases to pass over an adsorbent material 49 as shown in Figure 5. The adsorbent material may be one of the adsorbent materials mentioned above. The adsorbent material 49 is retained in place by porous supports 50 as shown in Figure 5. Other filters 51 may be provided to adsorb water. Other filters such for example as filter 52 may be employed to exclude bacteria, viruses or other particles. The gas or gases passing through the entire apparatus 48 shown in Figure 5 are substantially free of carbon dioxide so that the gas or gases can be returned to the apparatus shown in Figure 1 via a tube or passage (not shown) connecting with the entry port 17 shown in Figure 1.

When the person 43 inhales, oxygen, or an oxygen/air or gas mixture, are drawn via the tubes 44 and the mask

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42, via the non-return valve or valves, the optional humidifier and enter the person 43, a gaseous exchange takes place. When the person exhales, the moisture saturated carbon dioxide laden mixture of gases exhaled is returned to the flexible reservoir 2 via the non-return valve 7, connecting tubes and one or more filters, causing the reservoir 2 to expand vertically.

The flexible reservoir 2 is fitted with a rigid top 20, from which a rod 21 projects. The rod 21 may be a calibrated rod. The calibrations may correspond to the volume contained in the flexible reservoir 2. The rod 21 has an adjustable stop 22. The adjustable stop 22 is such that it can be fixed in any desired position, for example by a thumb screw 23. During use of the apparatus shown in Figures 1 and 2, the person 43 is instructed to inhale fully. The stop 22 is slid down the rod 21, until the stop 22 abuts an adjusting lever 24 and is fixed in this position. As the person 43 continues to breath, the rod 21 rises and falls. As the person 43 absorbs oxygen from the breathing mixture or pure oxygen contained in the flexible reservoir 2, the mean volume contained in the flexible reservoir 2 is diminished. Thus, as the person 43 inhales, the stop 22 brings pressure to bear upon the actuating lever 24. This causes the actuating lever 24 to lift the valve member 5 from its seat in the reservoir part 4, against the closing bias applied by a compression spring 25. Hydrogen peroxide 3 flows into the reaction chamber 7,

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where it decomposes to liberate oxygen. The liberated oxygen passes from the exit port 16 apparatus, via an optional drechsel bottle and/or a cold trap and/or one or more water adsorption filters, to the entry port 18. The oxygen entering the apparatus shown in Figure 1 via the entry port 18 replenishes the oxygen absorbed by the person 43, thereby maintaining the mean volume of gas contained within the apparatus and the person 43 within fixed limits.

The versatility of the apparatus shown in Figures 1 and 2 is increased by adjuster means in the form of a counter balance system. The counter balance system includes a counter balance weight 26 which is suspended from an inelastic flexible wire or line 27. The wire or line 27 runs over freely moving pulleys 28, and is attached to the end of the rod 21. When the counter balance system is balanced, the respiratory effort on the part of the person 43 is neither assisted nor hindered upon exhaling or inhaling. If an additional weight 29 is added to the reservoir top 20, the counter balance system is biased such that inhalation is assisted and exhalation is hindered. The hindering of the exhalation may be reduced or even reversed by motorising one or both of the pulleys via a motor 30. The motor 30 may be controlled by a switch actuated by either a pressure actuated switch integral with or proximal to the mask 42, alone or in conjunction with a switch operated by diaphragm movement or other respiratory related movement in the person 43.

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The apparatus shown in Figure 1 includes an electromagnetic clutch 31, or other equivalent mechanism, such that the motor 30 is only coupled when it is required to drive. In this arrangement, the apparatus shown in Figures 1 and 2 is a positive pressure ventilator.

In an alternative embodiment of the invention (not shown), a motor may be employed to drive a rack and pinion device, the rack being integral with the rod 21. This arrangement will allow the omission of the counter balance weights and the pulleys.

Various sensors and transducers may be included in any part of the air/gas flow of the apparatus shown in Figures 1 and 2. These various sensors and transducers may be employed for the electronic monitoring and/or control as desired.

A stop cock 32 has three positions. In a first position, a siphon tube 33 communicates to outlet via a drain 34. In this position, the operating level within the reaction chamber 7 is automatically maintained within levels A-C shown in Figure 1. This position can only be used for atmospheric or slightly above atmospheric pressure oxygen delivery. In a second position of the stop cock 32, the siphon tube 33 communicates with a drain outlet 35, and must be closed during high pressure oxygen delivery, and periodically opened to maintain operating level. In a third position of the stop cock 32, both drain outlets 34, 35 are closed as shown in Figure 1.

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It is to be appreciated that the embodiments of the invention described above with reference to the accompanying drawings have been given by way of example only and that modifications may be effected. Thus, for example, the person 43 may alternatively be an animal. Also, in all the apparatus described above, exhaled air only passes through the carbon dioxide filter during the exhalation period of the breathing cycle. Continuous flow through the filter may be achieved by the inclusion of a secondary bellows reservoir of smaller volume than the main reservoir (a volume only slightly larger than a subject's respiratory tidal volume) in the passage from the mask or mouthpiece or equivalent to the carbon dioxide filter. A small compressive bias may be applied to the secondary bellows by a weight or spring. The inflation pressure of the secondary bellows is less than the back pressure produced by the flow resistance of the filter, so that when a subject exhales, the secondary bellows inflate, then deflate via the carbon dioxide filter during the remaining parts of the respiratory cycle.

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CLAIMS

1. Apparatus for administering oxygen to a subject, which apparatus comprises connector means for connecting the apparatus to the subject such that the subject can inhale the oxygen, and filter means for filtering out carbon dioxide exhaled by the subject, the apparatus being such that the carbon dioxide is exhaled into the apparatus and mixes with the oxygen, the apparatus being such that the carbon dioxide is filtered by the filter means so that the oxygen remains substantially uncontaminated by the carbon dioxide and thereby remains suitable for inhalation.

2. Apparatus according to claim 1 in which connector means is a mask, a mouthpiece, an airway, or a helmet.

3. Apparatus according to claim 1 or claim 2 in which the filter means is a chemical filter means.

4. Apparatus according to claim 3 in which the chemical filter means is a lithium hydroxide, potassium hydroxide, sodium hydroxide, or soda lime chemical filter means.

5. Apparatus according to claim 1 or claim 2 in which the filter means is a molecular sieve filter means.

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6. Apparatus according to any one of the preceding claims and including passage means extending between the connector means and the filter means.

7. Apparatus according to claim 6 in which the passage means is a flexible tube.

8. Apparatus according to any one of the preceding claims and including adjuster means which is such that it can be adjusted for assisting or hindering inhalation and/or exhalation as may be desired.

9. Apparatus according to claim 8 in which the adjuster means is a counter balance device which is such that at balance it neither assists nor hinders the inhalation and/or the exhalation, and which is also such that it can be adjusted for assisting or hindering inhalation and/or exhalation as may be desired.

10. Apparatus according to claim 8 in which the adjuster means comprises a motor driving a rack and pinion arrangement.

11. Apparatus according to any one of the preceding claims and including a source of oxygen.

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12. Apparatus according to claim 11 in which the source of oxygen is hydrogen peroxide or compressed oxygen.

13. Apparatus according to any one of the preceding claims in which the apparatus is portable apparatus.

14. Apparatus for administering oxygen to a subject, substantially as herein described with reference to the accompanying drawings.

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INVESTOR IN PEOPLE

Application No: GB 0112229.0
Claims searched: 1-14

Examiner: Mark S Pritchard
Date of search: 1 October 2002

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.T): A5T TAB TAX TBC TCX

Int Cl (Ed.7): A61M 16/22

Other: WPI PAJ EPODOC

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	EP 0653219 A1	Tradotec S.A. (Whole document)	1 at least
X	US 5850833 A	Kotliar (Whole document especially column 10 lines 33-34)	1 at least
X	US 5566669 A	Komesaroff (Whole document especially Fig.1)	1 at least
X	US 5487380 A	Grabenkort (Whole document especially Figs 1 and 10)	1 at least
X	US 4353366 A	Bickford (Whole document especially Fig.1)	1 at least
X	US 4232667 A	Chalon et al (Whole document especially Figs 1 and 3)	1 at least
X	US 4108172 A	Moore, Jr (Whole document, especially Fig.2)	1 at least

X Document indicating lack of novelty or inventive step
Y Document indicating lack of inventive step if combined with one or more other documents of same category.
& Member of the same patent family
A Document indicating technological background and/or state of the art.
P Document published on or after the declared priority date but before the filing date of this invention.
E Patent document published on or after, but with priority date earlier than, the filing date of this application.